U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND

Abrams and Heavy Equipment Transporter Bridge Crossing Capability Analysis

Bernard Sia

General Engineer

TARDEC Bridging Research, Development, Test and Sustainment Team

AGENDA

- Introduction
- Vehicle Configurations
- Bridges
- Analytical Procedure
- Results and Discussion
- Summary

INTRODUCTION

- Vehicle crossing capability over military bridging may be unnecessarily restricted due to strict usage of Military Load Class (MLC)
- Analysis performed to assess differences in using vehicle MLC versus static analysis to determine tracked and wheeled vehicle crossing capability

VEHICLE CONFIGURATIONS

11 Vehicle Configurations assessed in analysis

- Focus on Abrams Tank, US Heavy Equipment Transporter

	Configuration	Weights (Short Tons)	MLC
Tracked	Abrams SEPv3 + Class I/II/III/V	73.51	79
	Abrams SEPv3 + Class I/II/III/V + FP Kits	78.92	95
	Abrams SEPv3 + Class I/II/III/V + FP Kits + APS + Ballast	81.43	104
	Abrams SEPv3 + Class I/II/III/V + FP Kits + Mine Plow	82.7	109
	Abrams (notional 85 tons)	85	119
	Abrams SEPv3 + Class I/II/III/V + FP Kits + APS+ Ballast + Mine Plow	85.21	120
	Abrams SEPv3 + Class I/II/III/V + FP Kits + Mine Roller	89.74	126
	Abrams SEPv3 + Class I/II/III/V + FP Kits + APS+ Ballast + Mine Roller	92.23	134
Wheeled	US HET with M1000 Trailer (B-Kit) + 80 ton load	128.959	107
	US HET with DOLL Vario S8H-0S2 Trailer + 80 ton load	136.98	134
	US HET with DOLL Vario S8H-0S2 Trailer + 85 ton load	141.98	139

6 Different Bridging Configurations Assessed

	Bridge	MLC (Normal Crossing)	MLC (Caution Crossing)
Tactical Bridging	Rapidly Emplaced Bridge System (REBS)	40T/ 40W	50T/ 50W
	Dry Support Bridge (DSB)	80T/ 96W	120W
Assault Bridging	Armored Vehicle Launched Bridge (AVLB)	95T	105T
Line of Communication Bridging	Line of Communication Bridge-Government (LOCB-GOV)	80T/ 100W	120T/ 150W
	Line of Communication Bridge-Operational Need Statement (LOCB-ONS)	85T/ 110W	123T/ 130W (Bridge A) 143T/ 138W (Bridge B)
	Line of Communication Bridge-Commercial Requirement (LOCB-CR)	120T/ 150W	150T/ 150W

ANALYTICAL PROCEDURE

Methodology 1 – Military Load Class (MLC)

- Compare vehicle's MLC to bridge's normal, caution crossing rating

Vehicle MLC < Bridge MLC → vehicle can cross bridge

Methodology 2 – Bending Moment/ Shear Force Comparison

- Max bending moment (BM), shear force (SF) due to actual vehicle over bridge span compared to that due to hypothetical vehicle
  - Impact, eccentricity included for normal crossing analysis; no impact/ eccentricity for caution crossing analysis

$$\left.\begin{array}{l} BM_{Actual} < BM_{Hypothetical} \\ SF_{Actual} < SF_{Hypothetical} \end{array}\right\} \text{actual vehicle can cross bridge}$$

NOTE: Global analysis performed only; local damage (e.g. deck cracking) not assessed

RESULTS

Methodology 1

Configuration	LOCB - GOV	LOCB - ONS	LOCB - CR	AVLB	DSB	REBS
Abrams SEPv3 + Class I/II/III/V	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NOGO
Abrams SEPv3 + Class I/II/III/V + FP Kits	CAUTION	CAUTION	NORMAL	NORMAL	NOGO	NOGO
Abrams SEPv3 + Class I/II/III/V + FP Kits + APS + Ballast	CAUTION	CAUTION	NORMAL	CAUTION	NOGO	NOGO
Abrams SEPv3 + Class I/II/III/V + FP Kits + Mine Plow**	CAUTION	CAUTION	NORMAL	NOGO	NOGO	NOGO
Abrams (notional 85 tons)	CAUTION	CAUTION	NORMAL	NOGO	NOGO	NOGO
Abrams SEPv3 + Class I/II/III/V + FP Kits + APS+ Ballast + Mine Plow**	NOGO	CAUTION	CAUTION	NOGO	CAUTION	NOGO
Abrams SEPv3 + Class I/II/III/V + FP Kits + Mine Roller**	NOGO	NOGO (Bridge A) CAUTION (Bridge B)	CAUTION	NOGO	NOGO	NOGO
Abrams SEPv3 + Class I/II/III/V + FP Kits + APS+ Ballast + Mine Roller**	NOGO	NOGO (Bridge A) CAUTION (Bridge B)	CAUTION	NOGO	NOGO	NOGO
US HET with M1000 Trailer (B-Kit) + 80 ton payload	CAUTION	NORMAL	NORMAL	NOGO	CAUTION	NOGO
US HET with DOLL Vario S8H-0S2 Trailer + 80 ton payload	NOGO	NOGO (Bridge A) CAUTION (Bridge B)	NORMAL	NOGO	NOGO	NOGO
US HET with DOLL Vario S8H-0S2 Trailer + 85 ton payload	NOGO	NOGO	NORMAL	NOGO	NOGO	NOGO

RESULTS CONT.

Methodology 2

Configuration	LOCB - GOV	LOCB - ONS	LOCB - CR	AVLB	DSB	REBS
Abrams SEPv3 + Class I/II/III/V	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NOGO
Abrams SEPv3 + Class I/II/III/V + FP Kits	CAUTION	NORMAL	NORMAL	NORMAL	CAUTION	NOGO
Abrams SEPv3 + Class I/II/III/V + FP Kits + APS + Ballast	CAUTION	CAUTION	NORMAL	NORMAL	CAUTION	NOGO
Abrams SEPv3 + Class I/II/III/V + FP Kits + Mine Plow**	CAUTION	CAUTION	NORMAL	NORMAL	CAUTION	NOGO
Abrams (notional 85 tons)	CAUTION	CAUTION	NORMAL	CAUTION	CAUTION	NOGO
Abrams SEPv3 + Class I/II/III/V + FP Kits + APS+ Ballast + Mine Plow**	CAUTION	CAUTION	NORMAL	CAUTION	CAUTION	NOGO
Abrams SEPv3 + Class I/II/III/V + FP Kits + Mine Roller**	CAUTION	CAUTION	NORMAL	NORMAL	CAUTION	NOGO
Abrams SEPv3 + Class I/II/III/V + FP Kits + APS+ Ballast + Mine Roller**	CAUTION	CAUTION	NORMAL	NORMAL	NOGO	NOGO
US HET with M1000 Trailer (B-Kit) + 80 ton payload	CAUTION	NORMAL	NORMAL	NORMAL	CAUTION	NOGO
US HET with DOLL Vario S8H-0S2 Trailer + 80 ton payload	CAUTION	CAUTION	NORMAL	CAUTION	CAUTION	NOGO
US HET with DOLL Vario S8H-0S2 Trailer + 85 ton payload	CAUTION	CAUTION	NORMAL	CAUTION	CAUTION	NOGO

DISCUSSION

Methodology 1 is more restrictive to vehicle crossing capability than Methodology 2

- Fewer “NOGO” results using Methodology 2
- Significant difference in crossing capability results for AVLB and DSB with Methodology 2 vs Methodology 1
- Span at which maximum MLC results may not correspond to that of actual bridge
- Use of MLC ignores actual effect of vehicle over specific bridge span
  - Mission performance, requirements specification may be adversely affected

SUMMARY

Crossing capability of 11 different vehicle configurations assessed over 6 different military bridging configurations

- Assessment performed using both MLC and Bending Moment/ Shear Force comparison

MLC found to be more restrictive to vehicle crossing capability than Bending Moment/ Shear Force comparison

BACKUP

ANALYTICAL PROCEDURE- METHODOLOGY 2

1. Calculate the maximum bending moment and shear force induced on each bridge by the actual vehicle.
   - For normal crossings, the maximum bending moment and shear force was scaled up by an impact factor of 1.15 (bending moment)/ 1.2 (shear force), as published in the Trilateral Design and Test Code for Military Bridging and Gap Crossing Equipment (TDTC), and an eccentricity factor.
   - For caution crossing evaluations, no eccentricity or impact factor is applied
2. Estimate the capacity of the bridge being evaluated by calculating the maximum bending moment and shear force induced on each bridge by the representative hypothetical vehicle for the bridge's MLC.
   - For normal crossing evaluations, the hypothetical vehicle representative of the bridge's normal crossing rating was used. The hypothetical vehicle's maximum bending moment and shear force is scaled up by impact factors published in the TDTC and an eccentricity factor to establish the normal crossing capacity.
   - For caution crossing evaluations of bridges with an established caution crossing rating, the hypothetical vehicle representative of the bridge's caution crossing rating was used for the evaluation. No eccentricity or impact was applied in this case.
   - For caution crossing evaluations of bridge without an established caution crossing rating, the normal crossing capacity was used, with the assumption that a caution crossing would result in the same effect on the bridge as a normal crossing.
3. Compare the values calculated in 1 and 2. If values calculated in Step 1 exceed either of the values calculated in Step 2, then the vehicle cannot safely cross the bridge.

ANALYTICAL PROCEDURE-METHODOLOGY 2 CONT.

Eccentricity applied as a factor, using the following formula:

$$f_{ec} = \frac{(W_b - 0.5 * W_t) + (W_b - W_v + 0.5 * W_t)}{W_b}$$

W_b = bridge width

W_v = vehicle width

W_t = track or wheel width.